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EXPERIMENTAL RESEARCHES UPON VASOMOTRICITY[1]

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THE facts which we have observed during the past few years, thanks to the surgery of the sympathetic system, seem to us incompatible with the classical ideas on the mechanism of vasomotor actions. They are precise facts, graphically registered, which anyone will be able to reproduce if he puts himself under the same conditions as we did. They seem to imply a revisal of the actual theories on vasomotricity. One will judge.

FIRST GROUP OF FACTS

1. If one removes, in man, the totality or almost the totality of the cervical sympathetic chain, one observes, at the level of the superior limb, after a very short phasis of increase in the arterial tension, a marked lowering of the pressure (5 cm. of Hg.), bearing on the maxima and on the minima. Then, after a few weeks, the arterial tension reaches again its preceding value and maintains it, usually a little below the pre-operative rate.

The modifications are bilateral; their evolutions are parallel and simultaneous on both sides. Sometimes they reach the four limbs where one observes everywhere and at the same time the same variations as previously indicated.

Then, after a few weeks, it becomes impossible to put in evidence the least vasomotor sign of a sympathetic neurotomy. There remains not a single trace of vasomotor paralysis. But, on the operated side, the reactions to external conditions do not take place any more (reactions to hot and cold baths by immersion of the hand belonging to the operated side).

Here is an example of it:

A man is submitted to the entire removal of the cervical chain down to the stellate ganglion (exclusively). One adds to this removal the section of all the rami coming from the stellate ganglion (C^6, C^7, C^8, D^1) and of the roots of the vertebral nerve. Before the operation, one had noted:

	On the right side	On the left side
Mx.	18	19
Mn.	9	6
Index	4.5	4

[1] Translated by Jean Verbrugge-Anvers.

and eight months later, one finds:

	On the right side	On the left side
Mx.	19	19
Mn.	10	10
Index	4.5	4.5

2. The resection of the stellate ganglion, which means practically the suppression of all the vasomotors of the upper extremity, has the same effects; the modifications are bilateral. After a few weeks, there is also a return to the preceding value and stabilization at that level.

Here is an example of it:

Mrs. L. is submitted, for asthma, to an extirpation of the right stellate ganglion. The day previous to the operation, the blood pressure had been:

	On the right side	On the left side
Mx.	13	13
Mn.	9	9
Index	3	3

21 months later, we find:

	On the right side	On the left side
Mx.	13½	13½
Mn.	9	9
Index	3½	2½

At the same time, the cutaneous temperature measures at the level of the pommels:

To the right ..... 36.5° To the left ..... 36.5°

and the tonometer of Gärtner shows at the level of the middle-finger:

On the right.... 14 cm. of Hg. On the left..... 14 cm. of Hg.

3. The results are the same if one cuts all the rami belonging to the superior limb, from C2 to D1 inclusively, including or not the branches of origin of the vertebral nerve.[2]

Here is an example of it:

A woman undergoes the section of all the rami of the neck from C2 to D1 inclusively for angina pectoris. One notes before the operation the following values:

	On the right side	On the left side
Mx.	12	11
Mn.	9¾	8
Index	¾	1¼

One year afterwards, day for day, we find:

	On the right side	On the left side
Mx.	12	12
Mn.	7½	7.5
Index	1½	1¼

When the circulatory conditions are thus reëstablished, generally speaking, the reactions of adaptation to heat and cold are once more normal. Only twice

[2] Leriche et Fontaine: Des modifications de la pression artérielle consécutives aux ramicotomies inférieures. Archives des maladies du coeur. Janvier, 1926, T. xix, p. 21.

were they incomplete; there was question in both cases of patients having undergone, on both sides, a resection of the rami of the brachial plexus and a humeral sympathectomy, once for a Raynaud's disease and once for sclerodermy. The study of the blood pressure gave, in one of these cases, the following results:

Before intervention:

At rest:	On the right side	On the left side
Mx.	14	15
Mn.	5	6
Index	3	4
After a cold bath:	On the right side	On the left side
Mx.	11	11
Mn.	6	6
Index	2	2

17 months later:

At rest:	On the right side	On the left side
Mx.	12	13
Mn.	7	7
Index	3½	5½
After a cold bath:	On the right side	On the left side
Mx.	12	12
Mn.	7	7
Index	3	5

In the other case, it was almost identical. One conceives, however, very well that, after a particularly extensive neurotomy, one may easily lose the possibility of adaptation of the extremities to the external conditions.

4. Likewise, the cutting of the lumbar chain, between the second and third ganglion for example, the section of all the lumbar rami are followed by an active vasodilatation which lasts from three to four weeks and ceases by and by, allowing the normal conditions to reappear gradually. Here again, the modifications are parallel in their evolution and take place bilaterally.

5. In man, we have not resected the whole lumbar chain, but we have noted that the extirpation of a single ganglion has the same effects as ramisection. In the dog, two months after the unilateral extirpation of the lumbar sympathetic system (ganglions L2, L3 and L4), blood pressure simultaneously registered in both femoral arteries with two manometers of François Frank, is rigorously similar on the operated side and on the healthy one.[3] The vasomotor reactions produced by any of the usual procedure are the same on both sides as far as the sense of the reaction and its value are concerned.

[3] One knows, however, that Claude Bernard has noted in a dog, eighteen months after the extirpation of the superior cervical ganglion, a persistent vasodilatation with hyperthermy at the level of the paw. But one may have a persistent hyperthermia in cases where the pressure has come back to the normal.

In one case, we have seen, after a year, the temperature of the peripheric parts remain 4° below the temperature of the opposite side, while the pressure and the oscillometric index had come back to the normal.

After all, the section of all the rami, said to be vasomotor, of a limb, never produces any durable trouble of vasomotricity and especially never does it bring about any vasomotor deficit.

Here are some more facts which will help to testify in the same way:

6. The liberation of the median cervical chain, the extirpation of the median cervical ganglion, produce a marked pharyngeal and laryngeal active hyperæmia, strong enough to reach sometimes the stage of an œdematous exudation. It lasts three to four days, then disappears completely without leaving trace.[4]

7. Periarterial sympathectomy brings about all the signs of an active vasodilatation and in a few weeks, the vasomotor reactions come back to the usual rate.[5]

8. The resection of an obliterated arterial cord[6] provokes a vasodilatation acting in the same sense as in periarterial sympathectomy, with active local hyperæmia and hyperleucocytosis.[7] Vasodilatation is more persistent than after sympathectomy, but it always tends to come back to normal.

9. In certain rather particular cases (Buerger's disease) where one finds obliterated venous cords under the skin, the resection of one of these cords produces a momentaneous active vasodilatation of the same type as the arterial resection.

After all, there is no sympathetic operation which would be followed by vasoparalytic phenomena. All those which we have been able to perform on men (and those which we have been able to perform experimentally on animals in a similar way) have been rapidly followed by an active temporary vasodilatation which does not remain localized to the downward territory, but usually extends to the limbs.

After more than 300 sympathetic operations at all levels, we do not know yet at which level we should act in order to reach vasodilator nerves. Everything happens as if there were none, although, however, the vasodilator actions are constant. It does not seem that up to now these surprising observations have impressed the physiologists.

Another new fact which should be put forward is the bilaterality and even the generalization to the four limbs of vasomotor actions produced by any sympathetic section. This fact alone is sufficient to show the impossibility in which we are to continue admitting the classical theory, which pretends to see in peripheric sympathetic nerves, centrifugal nerves, going from the medulla to the vessels with ganglionar interruptions.

[4] Leriche et Fontaine: Faits chirurgicaux touchant l'innervation sympathique du larynx et du pharynx. La Presse Médicale, Septembre 22, 1926.

[5] Leriche et Heitz: Des effets physiologiques de la sympathectomie periphérique. C. R. de la Soc. Biologie, Févr. 20, 1917.

[6] Leriche et Heitz: De la réaction vasodilatatrice consécutive à la résection d'un segment artériel oblitéré. C. R. de la Société de Biologie, Février 3, 1917.

[7] Leriche et Fontaine: De l'influence des opérations sympathiques sur la leucocytose. La Presse Médicale, Sept. 4, 1926.

SECOND GROUP OF FACTS

The cutting of some sensory nerves produces the same phenomena of vasodilatation as the sympathetic operations.[8]

Refrigeration of mixed nerves has the same hyperæmic effects.[9]

The extirpation of neuromas of cicatrization of mixed nerves acts exactly in the same way.[10]

In all these conditions, one has only observed phenomena of active vasodilatation. Never have we seen any paralytic phenomena and never any vasoconstrictor phenomena. Likewise, the section of a mixed nerve, like the sciatic nerve in man, never abolishes the active vasomotricity. It does nothing else but disorder the local vasomotor reactions. Several months after the section, one is able to observe very marked hyperæmic crises with rise in temperature of several degrees above normal.

THIRD GROUP OF FACTS

The section of the medulla which is supposed to produce paralytic vasodilatation, leaves unchanged the normal vasomotor reactions. We have seen, after an extensive destruction of the dorso-lumbar medulla (D8 to D10) all the vasomotor reactions persist at the level of the inferior limbs, at the end of three months. The pressure and the oscillations were subnormal (there was œdema present). An intravenous injection of a quarter of a milligram of adrenaline and in intradermic injection of a weak quantity of an extensive solution of adrenaline were followed by the usual reactions; the same result was obtained with hot and cold baths. A periarterial sympathectomy had been followed with the usual vasoconstrictive and vasodilator reactions, without the least quantitative variations.[11]

In dog, after section of the medulla, vasomotor reactions are not modified, even if one adds to the myelotomy an extirpation of the lumbar sympathetic chain or a section of the sciatic or both of them. Albert,[12] in his complete experimentation on vasomotor reflexes has always seen the traumatic vasomotor reflexes persist, even after section of the medulla, sciatic and crural nerves.

These facts seem to us incompatible with the existence of classical centri-

[8] de Nabias: Des résultats immédiats de la neurotomie sympathique simple dans les cas d'ulcères variqueux. XXXème Congrès français de Chirurgie, Octobre 5, 1921, p. 447.

[9] Laewen: Vereisung des Nervus Ischiadicus und des Nervus saphenu bei angiospastischen Schmerzzuständen der unteren Extremität. Münch. Med. Woch., 1922, T. lxix, No. 11, p. 389.

Laewen: Ueber Nervenvereisung bei angiospastischen Schmerzzuständ. Zentralblatt für Chirurgie, Septembre 1, 1923, T. l, No. 35, pp. 1346–1350.

[10] R. Leriche et R. Fontaine: Modifications vasculaires consécutives à l'ablation d'un névrôme du plexus brachial. Réunion neurologique de Strasbourg, Décembre, 1925, in Revue Neurologique, 1926.

[11] R. Leriche et R. Fontaine: Sur l'état de la vasomotricité après section de la moëlle. Soc. de neurol. de Strasbourg, 1926, vol. xl, p. 14.

[12] Albert: Etude exp. des troubles vaso-moteurs réflexes. Arch. Int. de physiol., Mai. 31, 1924, f. 4, T. xxii.

fugal vasomotor nerves, going from the medulla to the periphery, the ones being loaded with vasoconstrictive impulses, the others with vasodilator impressions. Our operations on the rami and on the lateral chains do not allow us to think that, if such are things, it is due to the fact that vasodilators get exhausted before reaching the periphery, as have said certain physiologists.

How could we explain this apparent disagreement between facts and theory?

One single hypothesis seems possible: One has to refer to the periphery the place of production of vasomotor actions which regulate the local circulations. One admits to-day the existence of vasomotor centres at the level of the arterial walls. One may suppose that, between these intra-arterial centres and the ganglionar and medullary centres, there are only sensory connections, fibres of association, of ortho- and anti-dromic conduction after the manner of Bayliss. The physiologists do well admit an influence of these intramural peripheric centres, but they seem to think that they only enter into activity after suppression of the medullary influence.

The facts which we have observed in man seem to show that they play a predominant rôle in the normal circulation, that, they alone, secure the motor actions, these actions being regulated by excitations, centrifugal and centripetal, coming from all parts of the body and going through the rami.[13]

One thing lacks to this hypothesis; that is the proof of degeneration after sympathetic neurotomy and this proof is indispensable for the elaboration of a valid theory of vasometricity. We do not ignore that, up till now, the method of degenerations has led to conclusions absolutely contrary to the one which we had to adopt. Langley seems to have established through studies of degenerations that all the sympathetic cells gave rise to centrifugal fibres and never to centripetal fibres. Gaskell has concluded from his research that the sympathetic system was only made of motor fibres and did not include a proper reflex arch. Bayliss also has insisted on this characteristic of the sympathetic system.

However, the facts which we have reported do not allow to admit this conception. They also must be taken into consideration. And without wanting to propose a general theory on vasomotricity, we think that, from now on, the old theory should be discarded, the facts observed in man being incompatible with it.

[13] R. Leriche: Les indications et les résultats de la section des rameaux communicants dans la chirurgie de la douleur. Grourement Belge d'etuds neuro-chirurgicales, Novembre 14, 1926.